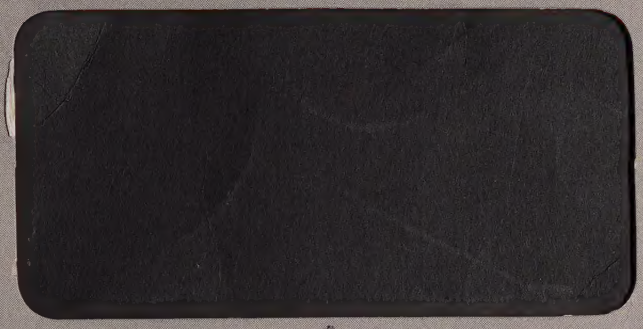
instruction manual



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Berkeley Division

30123

INSTRUCTION MANUAL

MODEL 5350
DIGITAL VOLT-OHMMETER

Serial No. 221

NOTE

If model number is followed by an inked letter, the instrument covered by this manual has been modified. See section on modifications.

Beckman/Berkeley Division
Richmond 3, Calif.

December 1958

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

(a) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect.

(b) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.

(c) The Company shall be released from all obligations under its warranty in the event repairs or modifications are made by persons other than its own service personnel or authorized representatives' personnel unless such repairs by others are made with the written consent of the Company.

(d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

(f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.

(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

BERKELEY DIVISION
BECKMAN INSTRUMENTS, INC.

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MODIFICATIONS

DRAWINGS

Input Circuit, Schematic Diagram, Dwg. No. 5350 C 3
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Display Circuit, Schematic Diagram, Dwg. No. 5350 C 4
Power Supply, Schematic Diagram, Dwg. No. 5350 D 1

APPENDIX

Instruction Manual for Model 705AK DCU

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1. INTRODUCTION

1.1 GENERAL DESCRIPTION

This instrument is a digital DC voltmeter equipped with circuits for measuring resistance and AC voltage as well. For resistance measurements, the meter sends a constant current through the unknown and measures the DC voltage developed across it. AC readings are obtained by amplifying and rectifying the AC signal, then measuring the resulting DC potential.

Full scale voltage ranges are: 1, 10, 100 and 1,000 volts DC; 1, 10, 100 and 500 volts rms. Full scale resistance ranges are: 10K, 100K, 1M and 10M ohms.

While a comprehensive description of the instrument's technical characteristics appears in Section 1.2, the following features are worthy of special mention. A single probe is used for all types of measurements, DC voltage, AC voltage and resistance. To eliminate operating errors, the illuminated display includes an indication of the type of measurement, the polarity (if any) and the position of the decimal point. To provide for automatic recording of measurements, the instrument makes available binary-coded readout signals suitable for driving a Beckman/Berkeley digital recorder.

Routine calibration of DC voltage, AC voltage and resistance can be done without auxiliary equipment because the instrument has internal standards which have been brought out to the front panel for this purpose.

1.2 TECHNICAL CHARACTERISTICS

GENERAL CHARACTERISTICS

Type of Indication

Three illuminated decimal digits (000 to 999) with a fourth ("1") to permit off-scale readings up to 1500. The digits indicate voltage or resistance, with decimal point shown as an illuminated dot.

Sampling Rate

The instrument makes successive measurements at a rate variable from one sample every four seconds to ten samples per second. Sampling may be triggered by an external control signal at rates of up to 20 samples per second.

Electrical Readout

The instrument produces a binary-coded parallel readout at a rear-panel socket. This is a four-line signal for each of the four digits, the type of measurement, polarity, and decimal point position. A Beckman/Berkeley digital recorder, connected

to this socket, will print out four digits together with other numbers indicating type of measurement and polarity.

Signal Ground

Input ground terminal is isolated from the chassis. This terminal may be established at any voltage level up to ±500 v with respect to chassis.

Power Requirements

117 v ±10%, 60 cps, approximately 150 watts.

Weight

36 lbs.

Dimensions

Mounted in carrying case 13 in. high, 9 in. wide, 15 in. deep.

DC VOLTAGE MEASUREMENTS

Measuring Ranges

1, 10, 100 and 1,000 volts full scale. Will give readings up to 150% of full scale on three lower ranges. Polarity automatically indicated.

Input Impedance

11 megohms

Linearity

±0.1% of full scale from zero to 100% of full scale.
Down 0.2% of full scale at 120% of full scale.
Down 0.3% of full scale at 150% of full scale.

Zero Drift

Maximum zero drift is ±0.3% of full scale per hour, ±1.0% per 8-hour period, ±1.5% per 24-hour period. Zero drift correction is a simple front panel adjustment.

Gain Variation

Maximum variation is ±0.2% in 24 hours. Gain correction is a simple front panel adjustment using an internal standard voltage.

AC VOLTAGE MEASUREMENTS

Measuring Ranges

1, 10, 100 and 500 volts rms full scale. Reads up to 150% of full scale on three lower ranges. Calibrated to indicate rms value of pure sine wave.

Measuring Mode

Operates on zero-to-peak value of input signal.

Frequency Range

50 cps to 50 kc

Input Impedance

1 v range: 10 megohms, 250 $\mu\mu$f
Other ranges: 10 megohms, 200 $\mu\mu$f

Linearity

±0.1% full scale from 10% to 100% of full scale indication

Zero Drift

Same as for DC measurements

Gain Variation

Maximum variation is ±0.3% in 24 hours.

RESISTANCE MEASUREMENTS

Ranges

10K, 100K, 1M and 10M full scale

Method of Measurement

Instrument passes a constant current through the unknown resistance, measures DC voltage developed across unknown.

Linearity

When calibrated at full scale, maximum deviation is +0.5% of full scale at 50% full scale, -1.0% at 150% full scale.

Zero Drift

Same as for DC voltage measurements.

Gain Variation

Same as for DC voltage measurements.

Variation in Current Through Unknown

Not more than ±1% in 24 hours.

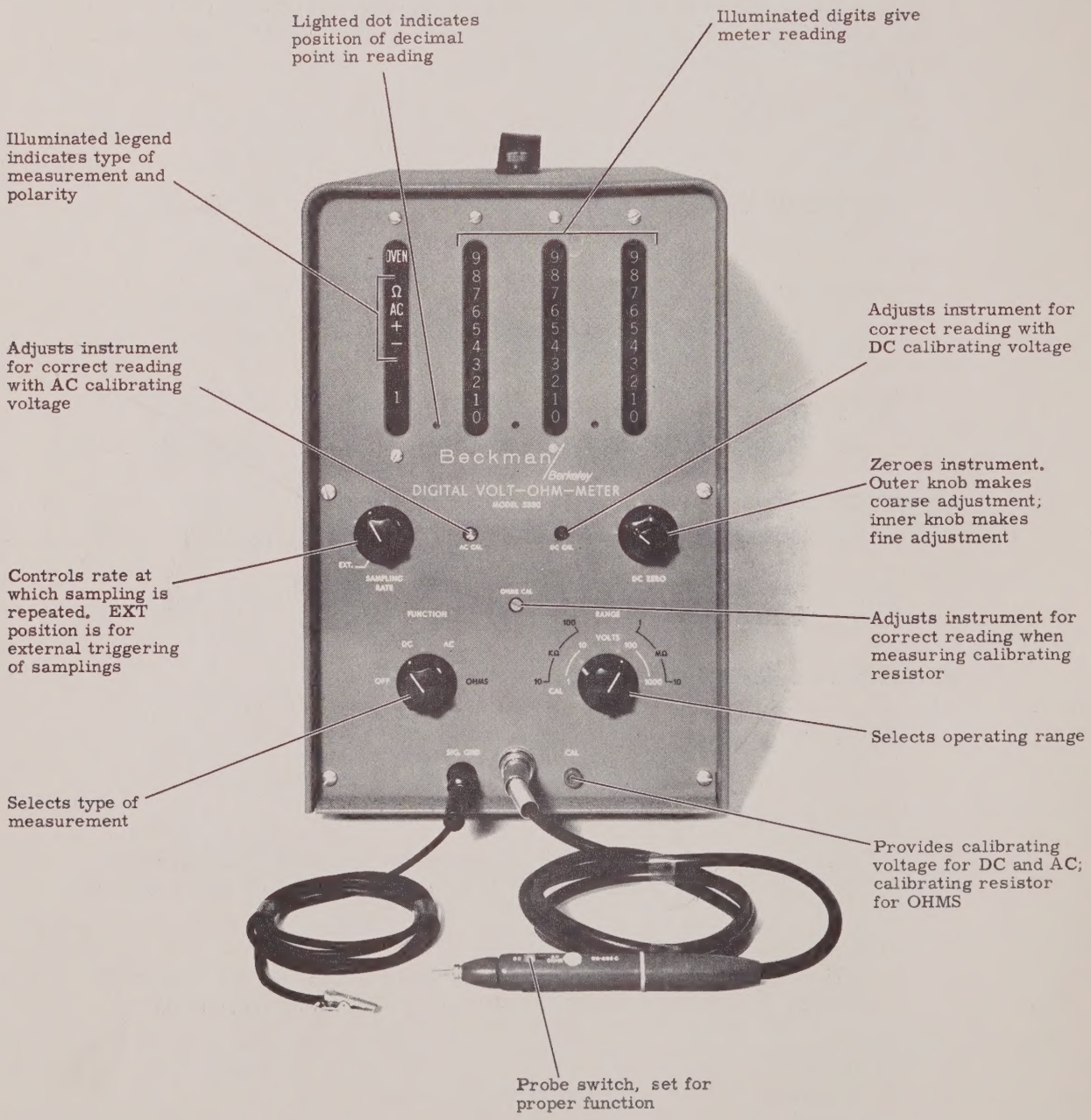


FIGURE 1 OPERATING FEATURES OF MODEL 5350

2. OPERATION

2.1 INSTALLATION

The instrument may be operated at any location convenient to a source of AC line power. Power requirements are 150 watts at 117 v ±10%, 60 cps. If the available power socket has a third-terminal ground connection, use the three-prong plug at the end of the power cable. Where only two-terminal sockets are available, use a three-prong to two-prong adapter plug.

2.2 APPLYING POWER

With the FUNCTION switch at OFF, line power is disconnected from the main power transformer. Whenever the FUNCTION switch is moved to some other position than OFF, all circuitry becomes energized. In order to achieve specified accuracy the instrument should warm up one-half hour before use. During this period the oven containing the voltage reference diodes will have time to reach a stable operating temperature.

2.3 HOW TO MEASURE DC VOLTAGES

2.3.1 DC Zero Adjustment

Before attempting any type of measurement (DC, AC or ohms), the operator should adjust the instrument to DC zero. This is done as follows:

(1) Position the FUNCTION switch at DC.

(2) Position the sliding switch on the probe at DC.

(3) Position the RANGE switch at "1" on the VOLTS scale.

(4) Attach the SIG GND clip lead to the tip of the probe.

(5) Adjust the SAMPLING RATE control for maximum rate (fully clockwise).

(6) Rotate the concentric ZERO adjust controls until the instrument reads as near 0.000 as possible. Use the outer knob for coarse adjustment; the inner knob for a final, fine adjustment.

    Due to the characteristic action of the gating circuits, the lowest possible reading will usually be "0.001". This is a normal "zero" indication. When you have achieved an ideal adjustment, the polarity sign will switch randomly back and forth between "+" and "-".

2.3.2 DC Calibration

The DC calibration should be checked periodically and, if necessary, adjusted to compensate for long-term drift. The procedure is as follows:

Immediately after the DC zero adjustment and before changing any control positions, insert the test probe into the CAL jack on the front panel. If ideally calibrated, the instrument will register 1.000 v. Some deviation from this value is to be expected. The amount of deviation will reveal the percentage error. A typical reading is 1.003, which indicates a DC calibration error of 0.3%. An error of this magnitude is insignificant except when attempting to make unusually accurate measurements. However, take note of the reading and, whenever error exceeds permissible tolerances, adjust the DC CALibration control for a reading of 1.000 v. (This is a front-panel, screwdriver control.)

The DC balance should also be checked periodically, and, if necessary, adjusted. To make this adjustment, proceed as follows:

Zero the instrument on DC volts. Connect any battery, first to indicate a positive voltage, then reverse the probe and signal ground lead for a negative polarity. If the plus and minus readings are not within one or two digits of each other, adjust R299 (BALANCE potentiometer) with a screwdriver. After balancing R299, recalibrate the instrument against the +1.000 volt reference jack. The battery voltage should be of a value to indicate approximately full-scale.

2.3.3 Taking a DC Voltage Reading

After the instrument has been "zeroed" and, if necessary, calibrated, you are ready to make a DC voltage measurement. The procedure is as follows:

(1) Position the FUNCTION switch at DC.

(2) Position the sliding switch on the probe at DC.

(3) The RANGE switch offers selection of four ranges denoted by full-scale values of 1, 10, 100 and 1,000 volts. Position it at the lowest value which exceeds the voltage under test. If you have no idea how high a voltage you are about to apply to the meter, start with the switch on the 1000 volt range. Operated on this range, the equipment will withstand potentials up to 1000 volts without damage. On the other ranges the maximum voltage which can be applied without danger of damage is five times the full scale value.

(4) Connect the SIGnal GND clip to one side of the voltage source and touch the probe to the other side. The applied voltage will be measured repeatedly. The result of each measurement appears in volts with an illuminated dot indicating the position of the decimal point and a "+" or "-" sign indicating polarity. The number of measurements taken per second can be varied from 1/4 to 10 by rotating the SAMPLING RATE control. Readings up to 150% of full scale will be displayed.

2.4 HOW TO MEASURE AC VOLTAGES

The procedure for making AC measurements is, in most respects, the same as that used for making DC measurements.

Preliminary Adjustments and Tests

(1) Make a DC zero adjustment with the FUNCTION switch at DC as described in section 2.3.1. There is no separate AC zero adjustment on the front panel.

(2) Check the DC calibration periodically as described in section 2.3.2.

Measuring Procedure

Follow the procedure for taking a DC voltage reading as described in section 2.3.3 with the following exceptions:

(1) Position the FUNCTION switch at AC. Notice that if you touch the probe to SIG GND, the instrument will register about 020. This is a normal "zero" indication at the AC position. DO NOT ATTEMPT TO RE-ZERO THE INSTRUMENT. The deviation from zero is due to nonlinear rectifier characteristics at very low values of applied voltage. This error disappears before applied voltage reaches 10% of full scale.

(2) Position the sliding switch on the probe at AC instead of DC. The indication will appear in volts rms assuming that the applied AC signal is a sine wave.

AC measurements employ the same circuitry used for DC measurements plus an AC input amplifier followed by a rectifier and filter. The accuracy of measurements is affected somewhat by changes in the gain of this amplifier; however, gain will not vary more than 0.5% in a 24-hour period. The gain of the AC amplifier can be adjusted with the AC CALibration control on the front panel. To do this, set the RANGE switch to the CAL position, insert the probe into the CAL jack on the front panel, and adjust the AC CAL control for an indication of 1.000 v rms.

2.5 HOW TO MEASURE RESISTANCE

Preliminary Adjustments and Tests

(1) Make a DC ZERO adjustment as described in section 2.3.1.

(2) Check the DC CALibration periodically as described in section 2.3.2

(3) Position the FUNCTION switch at OHMS.

(4) Position the sliding switch on the probe at OHMS.

(5) Position the RANGE switch at 10K.

(6) Insert the probe into the CAL jack, and adjust the OHMS CAL control for an indication of 10.00K ohms. (An internal 0.1% resistor is being measured in this case.)

Measuring Procedure

(1) The RANGE switch offers a selection of four ranges denoted by full-scale values of 10K, 100K, 1M and 10M ohms. Position the switch at the lowest value which exceeds the resistance under test.

(2) Connect the SIGnal GND clip to one side of the resistance to be measured and touch the probe to the other side. The resistance will be measured repeatedly at a rate determined by the position of the SAMPLING RATE control. On the two lower ranges, the reading appears in kilohms with an illuminated dot indicating the decimal point. On the two higher ranges, the result appears in megohms with a decimal point indicated.

(3) For best accuracy on the upper three ranges, it is advisable to first calibrate the instrument against a known 0.1% resistor with nominal value within 10% of the unknown.

2.6 SPECIAL OPERATING FEATURES

2.6.1 Floating Ground

The instrument has a signal ground system fully insulated from the chassis. This makes it possible to measure the potential difference between two points when neither is at earth ground potential. This feature can also be utilized to improve the accuracy of a high-voltage measurement. For example, suppose the voltage between two points, A and B, is approximately 450 volts. You can establish signal ground at 400 volts with respect to point B by connecting a battery or some other stable voltage source between point B and the SIGnal GND terminal. If the probe is then touched to point A, the instrument will read approximately 50 v -- the difference between the voltage being measured and the stable voltage. This low reading makes it possible to use the 100-volt range instead of the 1000-volt range, thus producing a reading with an extra significant digit and added accuracy. The potential difference between signal ground and the chassis may be as high as 500 volts without causing trouble. The impedance between SIG ground and PWR ground is 1M at 2μf.

2.6.2 Controlling Sampling with an Electrical Signal

If the SAMPLING RATE control is turned counterclockwise until a switch clicks, the instrument will not make a measurement until a negative pulse is applied to the EXT jack at the rear. This makes it possible to synchronize measurements with some external event of interest, or to create an extraordinarily slow sampling rate for long term voltage monitoring. The signal at the EXT jack must be a negative pulse at least 10 v high. Input impedance is 1M ohm.

2.6.3 Binary-coded Electrical Readout

Each decimal counting unit in the instrument generates a four-place binary code representing the digit it is displaying. The code appears in the form of a high or low voltage on each of four lines from each DCU. All these lines are collected at a multi-terminal socket at the rear. The socket carries all necessary digital information for the Model 1452 Digital Recorder or some other readout device. It also makes mutual control connections between the meter and the recorder.

3. SERVICING

3.1 COMPLETE CALIBRATION OF INSTRUMENT

3.1.1 Equipment Required

(1) DC Voltmeter with accuracy of .05% and minimum input impedance of 1 megohm (John Fluke Model 801 or equivalent).

(2) DC power supply with variable output from 1 to 500 volts; drift less than 0.1% over a one minute period.

(3) AC voltmeter, reading true rms voltage, with 0.25% accuracy and ranges of 1 v and 10 v.

(4) Source of pure sinusoidal signal between 50 and 150 cps with amplitude adjustable to 1 v and 10 v rms.

(5) 0.1% resistors with values of 10K, 100K, 1M and 10M ohms.

(6) A stable DC voltage source of any value near the scale limits of any DC range (e.g., a 1.5 volt dry cell or a 1.34 v mercury cell).

(7) A high quality oscilloscope with built-in square wave calibrator (Tektronix Model 531 or equivalent combination).

3.1.2 Adjustment Procedure

The following steps should be performed in the order listed.

(1) Adjusting Regulated B+ Supply

Measure +165 volt supply with a precision voltmeter and, if necessary, rotate B+ ADJ (R170) for a reading of 165.0 volts. Check -60 v, -150 v and +60 v supplies to make sure they are not fluctuating and are maintaining ±5% accuracy.

(2) Calibrating Internal Standard Voltage

Set the FUNCTION switch to DC and connect the precision voltmeter between the CAL jack (J103) on the front panel and signal ground. Adjust potentiometer R175 for a reading of 1.000 volts.

(3) Balancing Positive and Negative Scales

Using a stable DC voltage source with a value near the upper limits of a DC range, connect negative side of source to signal ground and positive side to probe. Observe positive voltage indication, then reverse polarity of applied voltage and observe negative indication. If the indications are not equal, adjust R299 for the same reading within ±1 in the least significant digit.

(4) Calibrating 1 Volt DC Range

Set probe switch to DC and connect probe to signal ground. Adjust DC ZERO controls for an indication of 000. Connect probe to the CAL jack, and position DC CAL control at center of rotational range. Adjust OSC ADJ. control (L201) for an indication of 1.000, and lock control. If locking causes indication to change, readjust DC CAL control for 1.000 indication.

(5) Calibrating 10 Volt DC Range

Apply a stable, DC potential of about 10 volts, known to within 0.1%. Adjust potentiometer R114 for a correct reading on the 10 volt range.

(6) Calibrating 100 Volt DC Range

Apply a stable, DC potential of about 100 volts, known to within 0.1%. Adjust potentiometer R117 for a correct indication on the 100 volt range.

(7) Calibrating 1000 Volt DC Range

Apply a stable, DC potential of about 500 volts, known to within 0.1%. Adjust potentiometer R120 for a correct indication on the 1000 volt range.

(8) Calibrating AC Amplifier

Set both FUNCTION switch and probe switch to AC. Connect probe and SIG. GND lead across a signal source generating a pure sine wave with a stable amplitude of approximately 1 v known to within ±0.25% of true rms value. Switch to the 1 v AC range, and adjust AC CAL control (R120) for correct digital indication. Switch to 10 v range and adjust AC ZERO control (R132) for a correct indication. Switch back and forth between 1 and 10 volt ranges checking indication and adjusting if necessary until both are correct.

Insert the probe into the CAL jack and, if necessary, adjust potentiometer R188 (right rear of DCU chassis) for a reading of 1.000.

(9) Calibrating 10 Volt AC Attenuator

Calibrate a scope probe against a 20 volt square wave calibrator signal. Connect the voltmeter probe to the calibrator output, and the scope probe to pin 3 of V102. Adjust capacitor C102 for a displayed waveform which is as flat-topped as possible.

(10) Calibrating 100 Volt AC Attenuator

Increase the square wave input to 100 v. Adjust capacitor C103 for a flat-topped waveform.

(11) Calibrating 500 Volt AC Attenuator

Amplify the square wave as near to 500 volts as possible. Recheck the calibration of the scope probe. Adjust capacitor C105 for a flat-topped waveform.

(12) Calibrating Resistance Range

Set both FUNCTION switch and probe switch to OHMS. With RANGE switch at 10 MΩ, measure a 10 megohm, 0.1% resistor with the digital meter and adjust OHMS CAL control (R108) for a reading of 10.00. With RANGE switch at 1 MΩ, measure a 1 megohm, 0.1% resistor and adjust potentiometer R180 for a reading of 1.000.

With RANGE switch at 100 KΩ, measure a 100K, 0.1% resistor and adjust potentiometer R106 for a reading of 100.0. With RANGE switch at 10 KΩ, insert probe into CAL jack and adjust potentiometer R107 for a reading of 10.00.

3.2 TUBE REPLACEMENT

The Differential Amplifier tube V103 is a Raytheon type 5755 which is selected for low grid current (2×10^{-9} a.) and high internal leakage resistance (minimum of 10^4 megohms, measured hot). For replacement purposes, this tube should therefore be ordered from Beckman/Berkeley.

There are no special requirements for any of the other tubes in the instrument.

MODIFICATION R

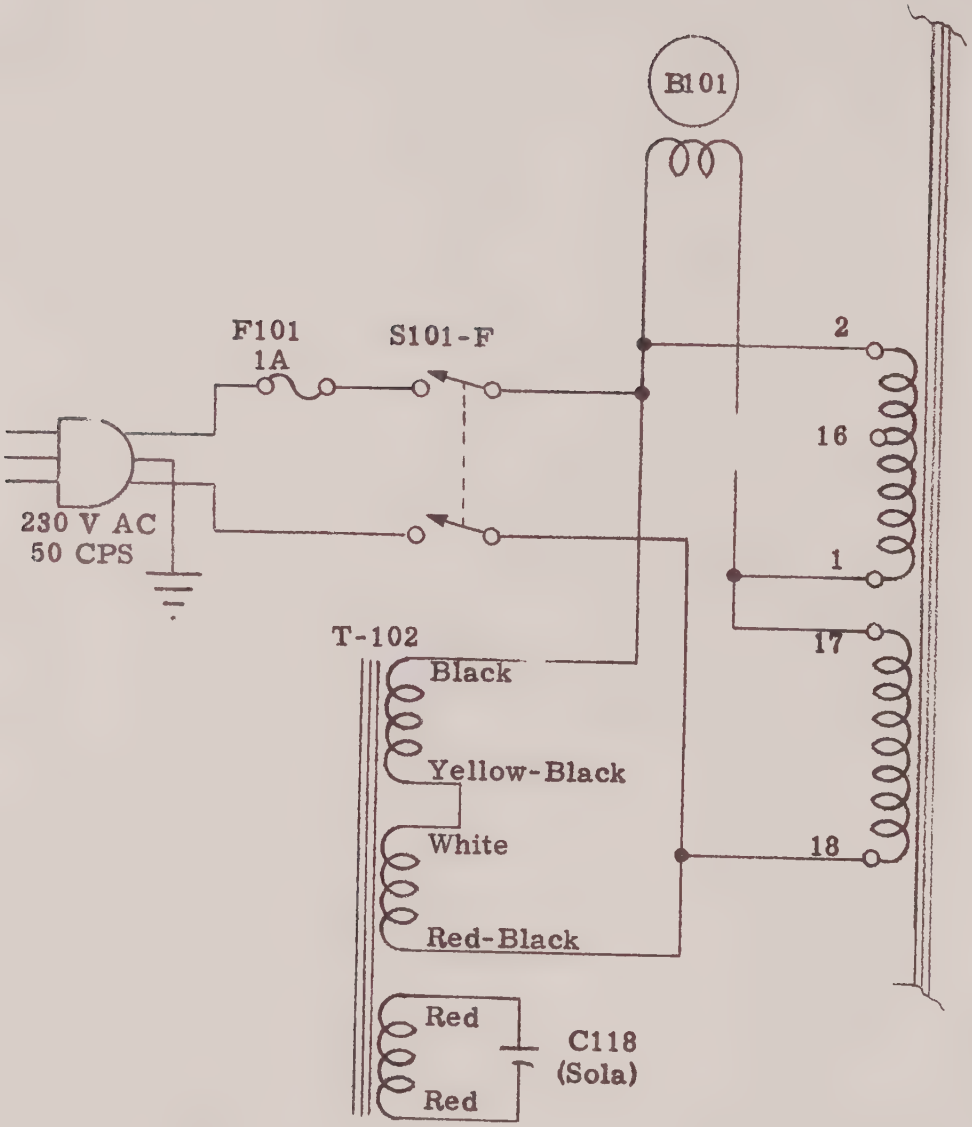
The Model 5350R is the rack-mount version of the standard Model 5350. Except for the use of a standard 19 inch rack panel, and the addition of a parallel input connector on the back, this instrument is the same as the portable model.

MODIFICATION H

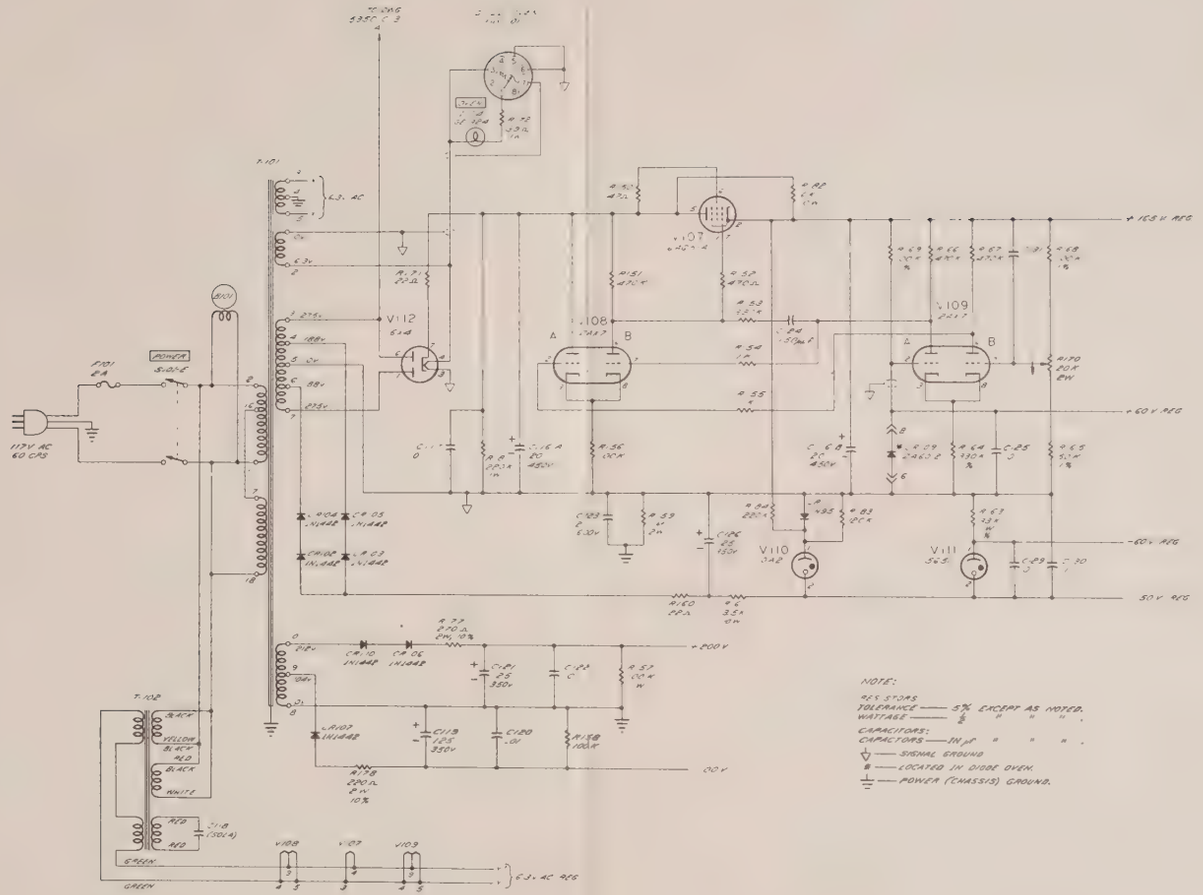
The Model 5350H is a standard Model 5350 instrument which has been modified to operate from a 220 volt, 50 cps AC line. The modification includes the following changes:

1) The primary windings of the transformers (T101 and T102) in the power supply have been rewired as shown on the schematic insert for this modification (see next page). Filament transformer T102 is a regulating transformer (Beckman/Berkeley part no. 6-7634) designed for a line frequency of 50 cps.

2) The line fuse, F101, has been changed from 2 amperes to 1 ampere.

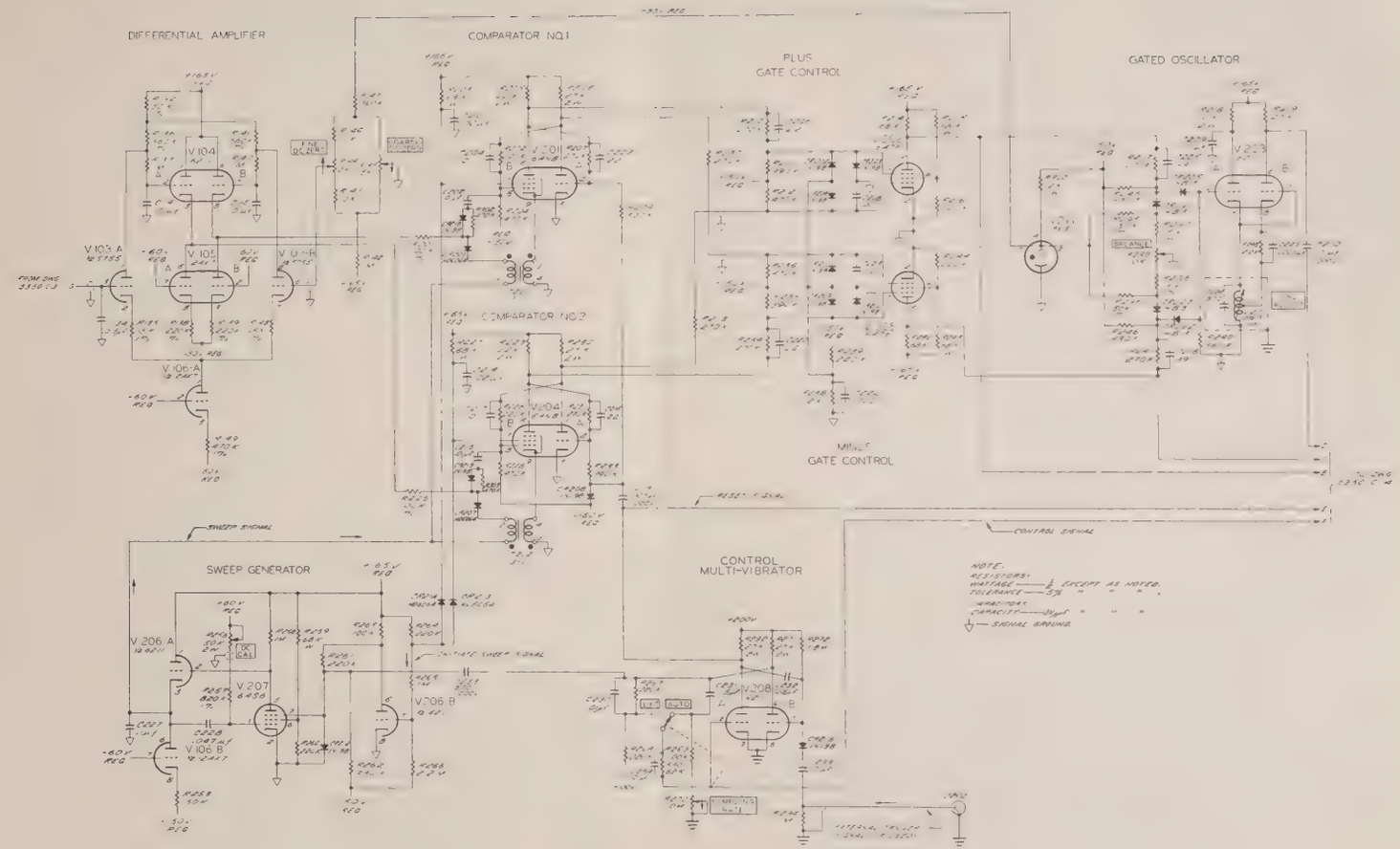


MODIFICATION H
SCHEMATIC INSERT FOR
POWER SUPPLY
(DWG. NO. 5350 D 1)



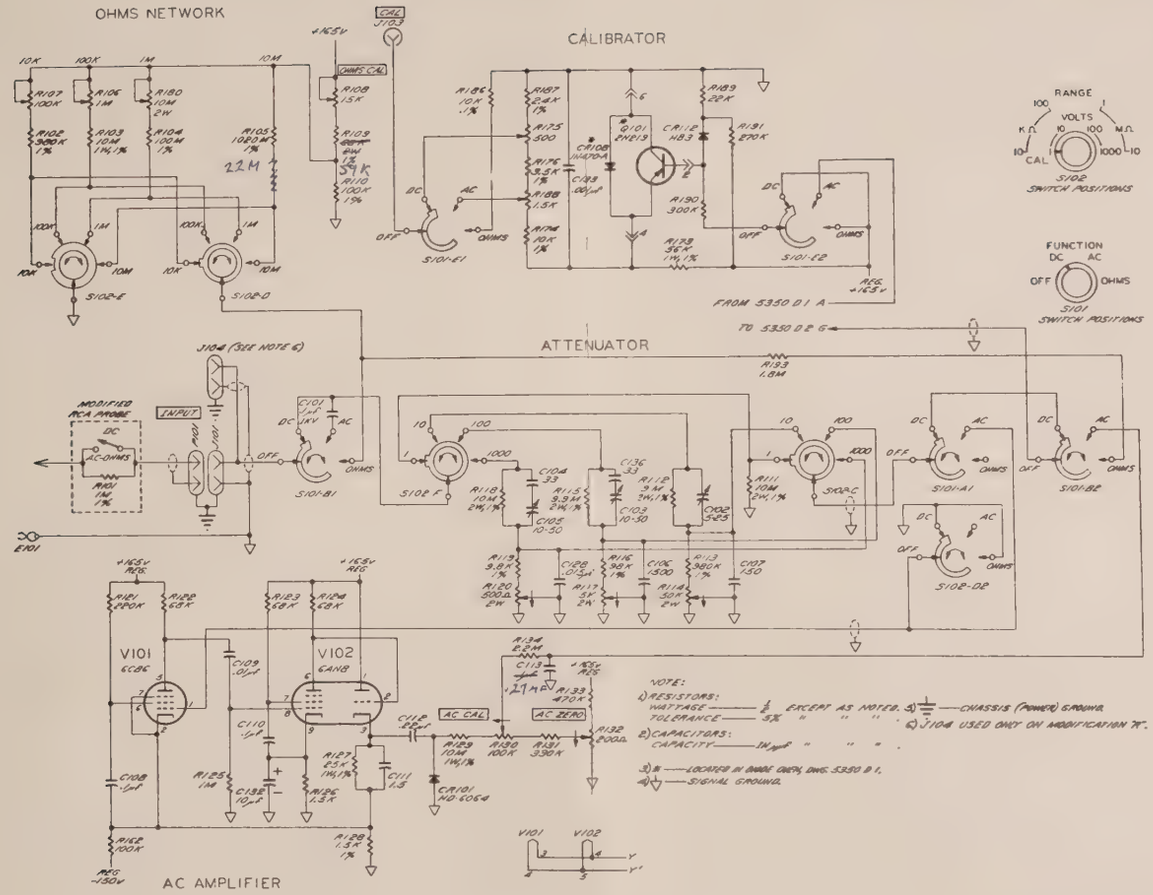
December 1958

MODEL 5350 DIGITAL VOLT-OHMMETER
POWER SUPPLY, SCHEMATIC DIAGRAM
DWG. NO. 5350 D 1



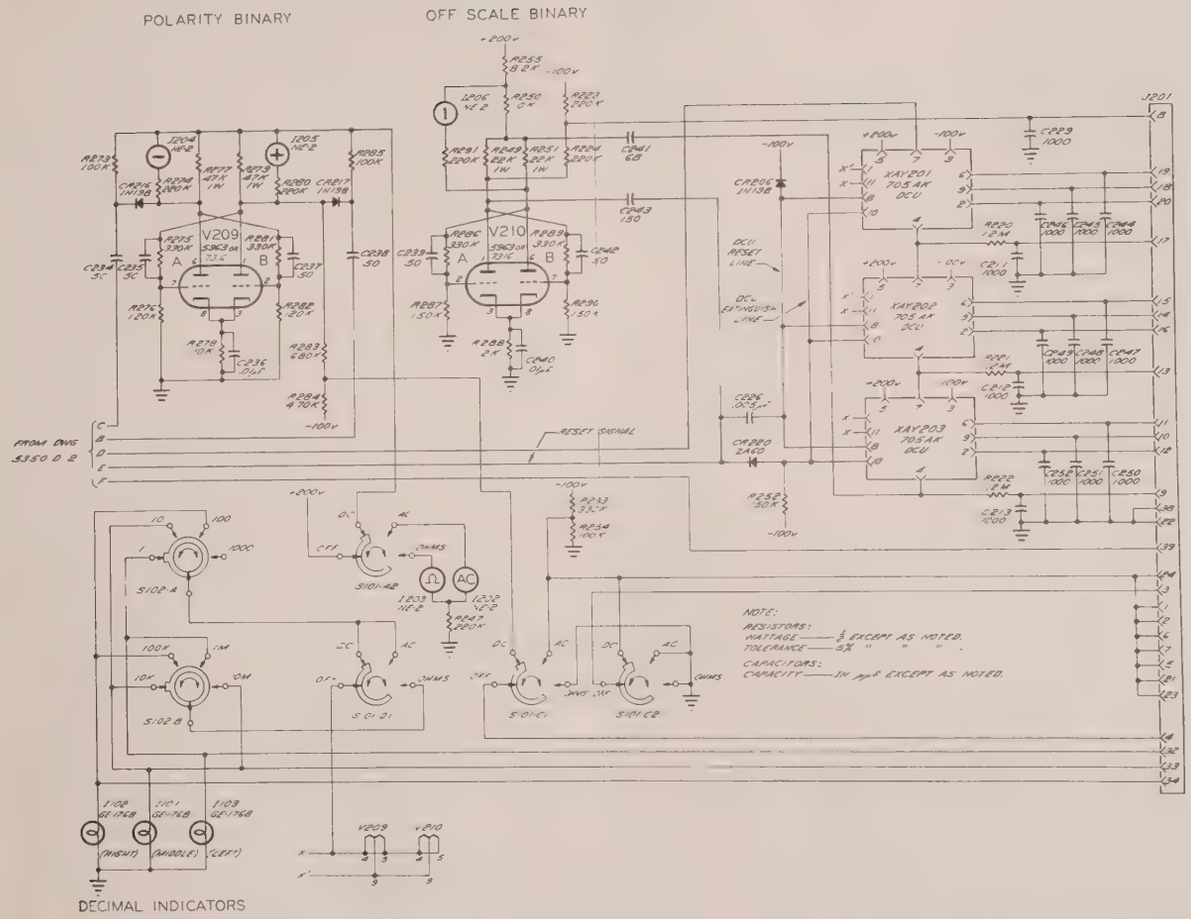
December 1958

MODEL 5350 DIGITAL VOLT-OHMMETER
CONTROL CIRCUIT, SCHEMATIC DIAGRAM
DWG. NO. 5350 D 2



MODEL 5350 DIGITAL VOLT-OHMMETER
INPUT CIRCUIT, SCHEMATIC DIAGRAM
DWG. NO. 5350 C 3

January 1959



MODEL 5350 DIGITAL VOLT-OHMMETER
DISPLAY CIRCUIT, SCHEMATIC DIAGRAM
DWG. NO. 5350 C 4

January 1959

INSTRUCTION MANUAL

Models 705AH, 705AJ & 705AK
DECIMAL COUNTING UNITS

Lot No.

BERKELEY division
Beckman Instruments, Inc.

Richmond 4, California
18 March 1957

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(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

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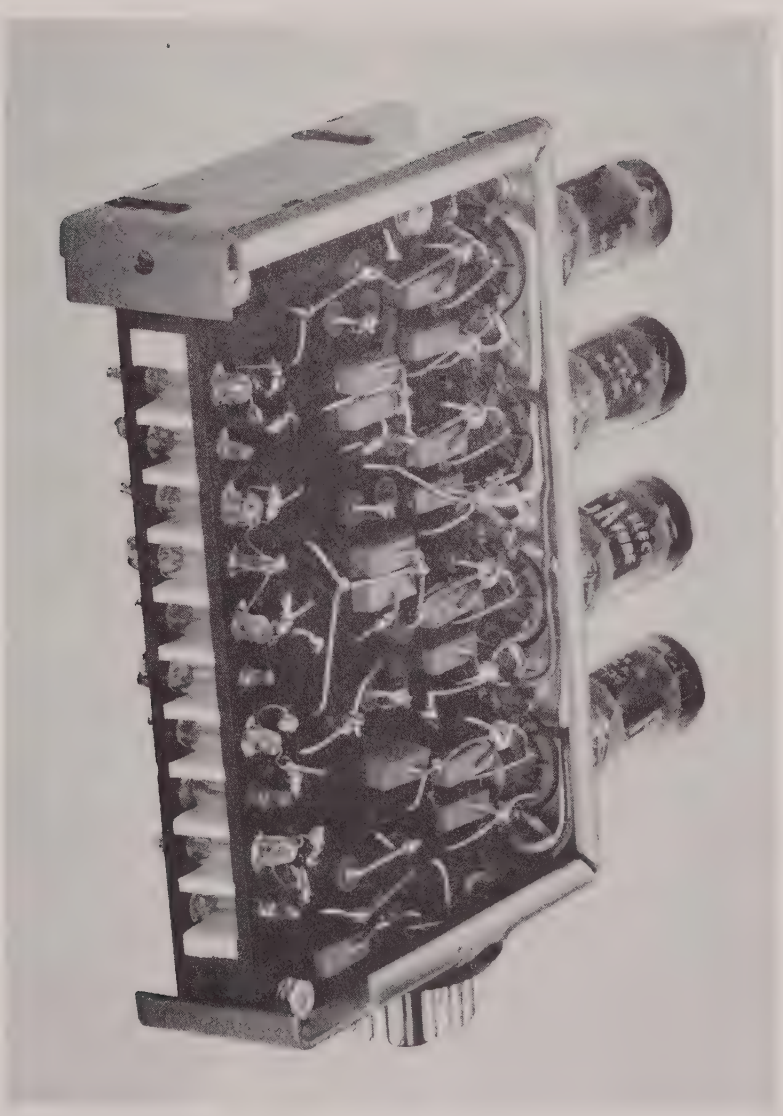

Model 705AH Decimal Counting Unit with
side covers and indicating panel removed.

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INTRODUCTION

These decimal counting units are direct-reading, plug-in electronic counters. The number of input pulses received is indicated by the illumination of one of ten neon lamps placed behind a numbered acetate panel. Each unit counts from zero to nine, the tenth pulse resetting the counter to zero and simultaneously generating an output signal. Any number of these units can be connected in cascade (the output of one unit driving the next) forming a counter whose total count capacity depends only on the number of DCU's. Thus, five units will count to 99, 999 resetting to "00, 000" on the 100, 000th pulse.

Models 705AH and 705AK generate a binary coded decimal readout. This code is in the form of high or low voltages at each of four pins on the DCU plug.

SPECIFICATIONS

Count Indication

Direct reading, decimal presentation

Power Requirements

Heaters: 6.3 v. at 1.2 amps

Plates: 300 v. at 13 ma

Input Requirements

Negative pulses (See "OPERATION")

Output Characteristics

Designed to drive a Model 705A DCU or any modification thereof (i.e., 705AH, 705AK, etc.)

Resolution of Paired Pulses

5 microseconds

Reset

Will reset to either zero or nine depending on polarity of reset pulse applied.

Maximum Counting Rate

100, 000 counts per second

Construction

Plug-in unit, 11-pin socket

OPERATION

Power Requirements. The heaters require 6.3 volts ac at 1.2 amperes. The plate circuits may be operated on from 200 to 400 volts, although the design center is 300 volts at 13 ma. Plate voltage may be applied in the form of B + and B - voltages. The d-c level of all output voltages will depend upon the level of the plate supply voltages.

Input Requirements. A negative pulse at least two microseconds wide is required to drive the unit. The optimum pulse amplitude depends on the rise time. With a rise time of 0.5 microseconds (measured between ten and ninety percent values) the pulse amplitude should be between 75 and 135 volts. With a two-microsecond rise time, the amplitude should be between 120 and 165 volts. When operating the plate circuits on 300 volts, optimum performance is obtained with a rise time of one microsecond or less and a pulse amplitude of 100 volts. If the unit is powered by unregulated d-c supplies, the input pulse amplitude should vary in phase with the supply voltage. The input load presented when an input pulse occurs is 15K ohms in series with 100 micromicrofarads.

Output Characteristics. The output is the rectangular waveform shown in Figure 3. As every tenth input pulse triggers the unit from count display "9" to count display "0", a negative transient occurs at pin 4 of the DCU plug. With a plate supply of 300 volts, the potential at pin 4 drops from + 135 to + 55 volts with respect to B-. This transient can be used to drive succeeding decimal counting units or other circuitry. The load impedance connected

between the output terminal and ground must not be less than 300K or 6K in series with 100 micro-microfarads.

Method of Resetting after a Counting Period. A DCU can be reset to a registered count of either zero or nine by the application of a voltage pulse of the proper polarity to the proper pin of the DCU plug. See the table below.

	RESET TO ZERO		RESET TO NINE	
	Pulse Polarity	Applied at Pin No.	Pulse Polarity	Applied at Pin No.
705AH	Neg.	8	Pos.	8
705AJ	Neg.	8	Pos.	8
	Pos.	3	Neg.	3
705AK	Neg.	8	Pos.	8

The reset pin (or pins in the base of Model 705AJ) should be maintained at the B- supply voltage except when a reset pulse occurs. A 50-volt pulse at least 3μseconds wide is adequate. A 100-volt pulse need be only 1.5μseconds wide. There is no maximum pulse width; however the DCU will not begin counting again until the reset pin returns to the B- supply voltage.

Simply disconnecting a reset pin from B- with a switch or relay will have the same effect as applying a positive pulse.

Binary Code Readout. Models 705AH and 705AK generate a modified binary code representing the decimal digit registered. The code appears in the form of a voltage (high or low) at one plate of each of four double-triode binaries. In the table below, "0" represents a plate voltage of approximately +55 volts with respect to B-; "1" represents a plate voltage of about +135 volts with respect to B-. (These are the voltage levels which appear when using a 300-volt plate supply.) Each of the four plates is coupled to a pin of the DCU plug through a 1.2 megohm resistor except in the case of pin 4 on the 705AK DCU. This pin is connected directly to a plate of the fourth binary. To obtain a readout voltage at this pin, it is necessary to add a 1.2M resistor externally.

DECIMAL DIGIT REGISTERED	FOUR - LINE BINARY CODE			
	1st Binary Stage (Pin 2 of DCU plug)	2nd Binary Stage (pin 6 of DCU plug)	3rd Binary Stage (Pin 9 of DCU plug)	4th Binary (Pin 10, 705AH) (Pin 4, 705AK)
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	1	1	0
5	1	1	1	0
6	0	0	1	1
7	1	0	1	1
8	0	1	1	1
9	1	1	1	1

Extinguishing the Indicating Lamps During the Counting Period. On Models 705AJ and 705AK, it is possible to prevent the neon bulbs from lighting by placing approximately -100 volts with respect to B- on pin 10 of the DCU plug. Ordinarily, the user will wish to extinguish the bulb while the DCU is actively counting, and to allow them to light, indicating the registered count at the end of a counting period.

CIRCUIT DESCRIPTION

The Binaries. The decimal counting units contain four "flip-flop" circuits. These circuits are slightly modified versions of the Eccles-Jordan trigger circuit. They are referred to here as binaries.

Figure 1 is a schematic diagram of a typical binary. It consists of two triode voltage amplifiers with the plate of each direct-coupled to the grid of the other. With no input this circuit assumes one of two stable states: V1 conducting steadily and V2 cut

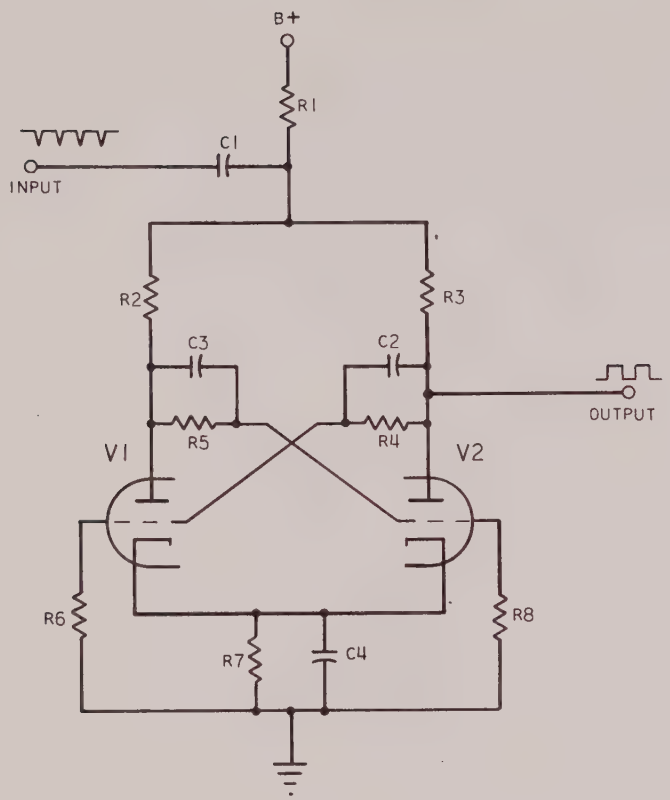


FIGURE 1. A TYPICAL BINARY.

off, or V2 conducting and V1 cut off. Suppose V1 is not conducting. Then, its plate is near the B- voltage. A portion of this voltage, applied to the grid of V2 through the voltage dividing network R5 and R8, raises this grid above cut-off and permits V2 to conduct. While V2 is conducting, the low positive potential at its plate, coupled to the grid of V1 through the dividing network R4 and R6, holds this grid several volts below cut-off. Since small changes in the potential at the grid of V1 will not raise it above cut-off, this state is stable and will persist until disturbed by an appreciable input signal. Notice that, since the circuit is symmetrical, the opposite state is equally stable.

The circuit is triggered from one state to another by negative pulses applied at the input. For example, assume that V2 is conducting and V1 is cut off. If a negative pulse is applied to the input, there is a drop in the plate voltage of V1. This drop in voltage is transmitted through a crossover network (R5, R8, C3 and the grid-to-ground capacitance of V2) and applied to the grid of V2. The plate voltage of V2 then starts to rise, carrying with it the grid of V1. If the input pulse is of sufficient amplitude, V1 begins to conduct. The moment V1 conducts, the drop in voltage at its plate, coupled to the grid of V1, reinforces the negative transient there. This regenerative action proceeds rapidly until V2 is cut off and V1 is conducting at a steady rate. The next adequate input transient causes a reverse action and returns the binary to its original state. Thus, the binary completes a cycle for every two input transients applied, making it a scale-of-two. The output is the drop in voltage at one of the plates as that triode begins to conduct. This output, consisting of one negative transient for every two input transients, is suitable for driving another binary. By connecting binaries in cascade (output of one to input of the next) a counter having a scale of any power of two can be built.

The Scale of Ten. In the Model 705A four binaries are connected in cascade forming a scale-of-16 which is permuted to a scale-of-10 by two positive feedback paths. (See Figures 2 and 3) For the first three negative input pulses, the unit operates like a simple binary counter. At the fourth input pulse, the third binary is triggered for the first time, sending a pulse through the first feedback path which triggers the second binary. Since it requires two input pulses to trigger the second binary, this is equivalent to adding two input pulses; therefore, the state of the unit now

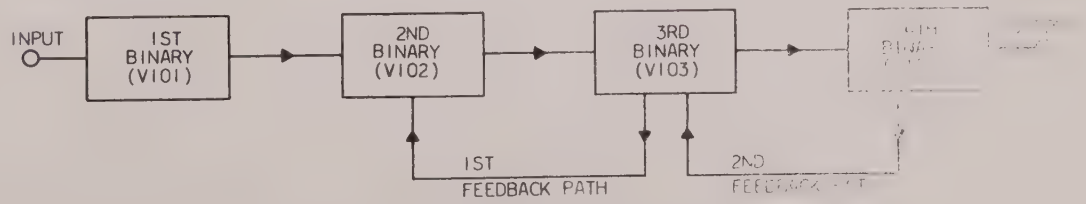


FIGURE 2. BLOCK DIAGRAM.

corresponds to a binary count of six. The sixth input pulse (equivalent to the eight in a simple binary chain) triggers the fourth binary which sends a pulse through the second feedback path, triggering the third binary. This is equivalent to adding four more input pulses so the state of the unit now corresponds to a binary count of 12. For the next four input pulses (7 thru 10) the unit operates again as a simple binary chain, producing an output pulse at the tenth input pulse. Adding the equivalent of six input pulses internally has changed the binary chain from a scale-of-16 to a scale-of-10.

When the third binary is triggered by a feedback pulse, it tends to retrigger the second binary in the same way that it did at the time of input pulse four. This tendency is offset by a simultaneous opposing signal from the fourth binary.

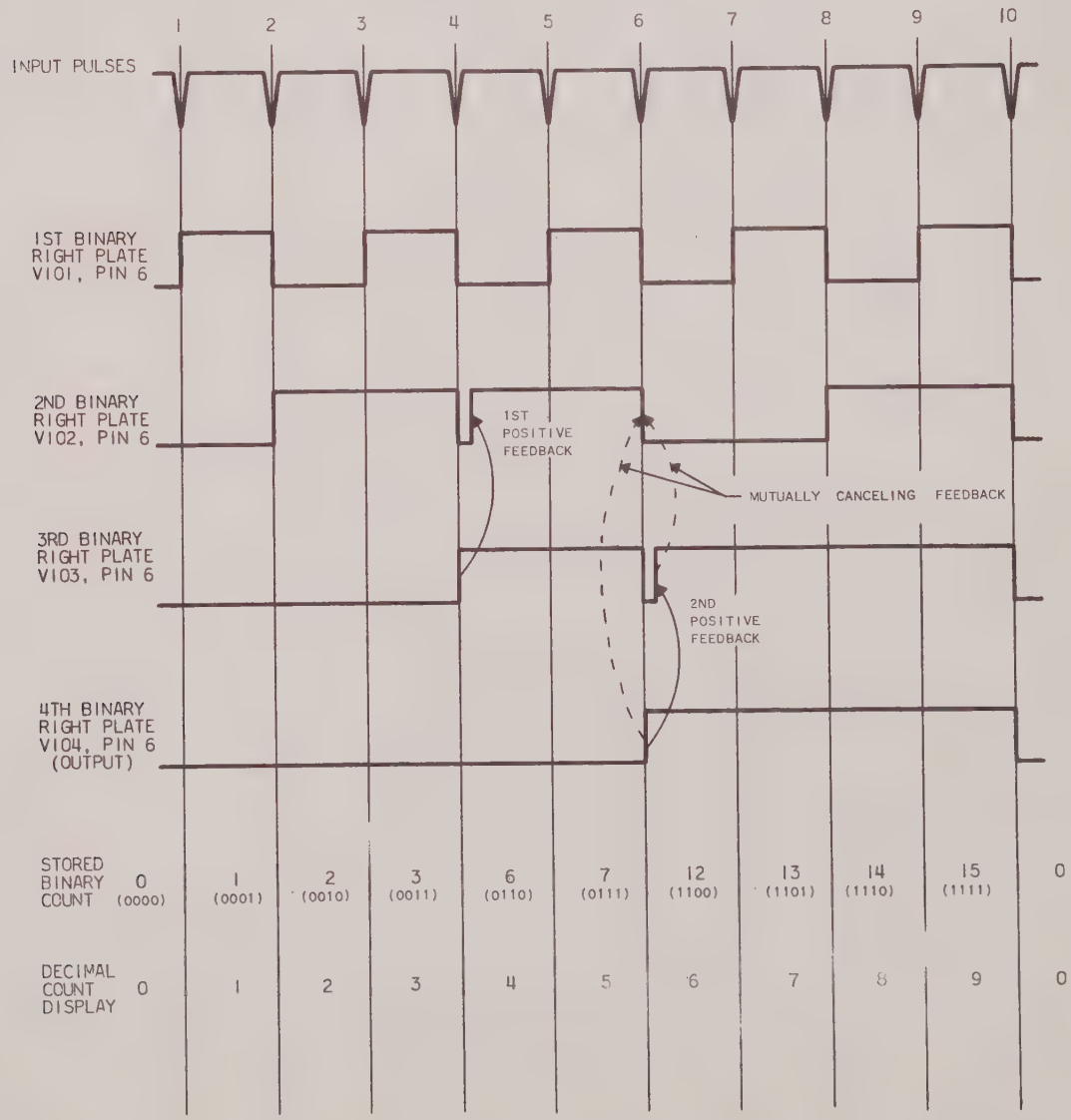


FIGURE 3. IDEALIZED WAVEFORMS. "RIGHT PLATE" REFERS TO THE PLATE APPEARING ON THE RIGHT-HAND SIDE OF THE BINARY AS DRAWN ON THE SCHEMATIC.

TROUBLESHOOTING PROCEDURES

When a decimal counting unit is suspected of counting incorrectly, it should be interchanged with another unit in the instrument or replaced with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully. Because the counting unit is usually the indicating device of an instrument, it is often accused of operating incorrectly when the fault is external to it.

Two methods are recommended for locating a defect in a DCU. The first is to observe the lighting sequence while driving the unit at a slow pulse rate. The second is to study the output waveform of each binary while driving the unit fast enough to create an oscilloscope display. It is impossible to say which method should be used in every case, since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first. The table of common troubles lists the probable defects indicated by particular variations from the proper lighting sequence. Binary output waveforms may be compared with the idealized waveforms of Figure 3 and the photographs appearing in Figure 4 & 5.

A table of typical voltages and resistances has been provided to help the serviceman locate a defect within one of the binary stages. Values may deviate considerably from those given without causing trouble. The fact that the unit is designed to operate at plate supply voltages ranging from 200 to 400 volts is a rough indication of permissable tolerances.

TROUBLESHOOTING CHART

NOTE: Reset unit to zero before testing for symptoms

SYMPTOMS	POSSIBLE CAUSES
Unit Fails to Count	(a) Insufficient supply voltage. (b) Input signal of insufficient amplitude (c) Input signal of wrong polarity. (d) First stage inoperative.
Unit Counts Spuriously	(a) Extraneous input signals. (b) Pulses received through power supply. (c) External voltages picked up by output lead.
Units Counts Erratically	(a) Input signal too large or small, incorrect rise time. (b) Supply voltage fluctuating too much.
Unit Fails to Reset	(a) Stray counts from reset switch or associated circuitry. (b) Defective component.

Units counts regularly but neon bulbs light in wrong sequence and the pattern of lighting is repeated consistently after a definite number of input pulses. One or more bulbs may be lit simultaneously during a cycle but the number of states per cycle remains constant.

1.	Units skips every other number	(a) First stage defective. (b) Input circuit supplies double pulses.
2.	Two stable states per cycle.	(a) Second stage defective(Display sequence may be 01 or 45). (b) Loss of drive to second stage (01).
3.	Four stable states per cycle.	(a) Third stage defective (Display sequence may be 0123 or 6789). (b) Loss of drive to third stage (0123).
4.	Six stable states per cycle.	(a) Output excessively loaded (Display sequence may be 012345). (b) Last stage inoperative (Display sequence may be 012345 or $67^{89}_{23}89$*. (c) Loss of drive to fourth stage (Display sequence may be 012345).
5.	Eight stable states per cycle or any failure where two successive numbers are skipped.	(a) Second or third stage failure.
6.	Ten stable states per cycle, but the lighting sequence is incorrect.	(a) When the wrong neon lamp lights, the trouble is usually a defect in the lamp that should have lit, but it may be a defect in the lamp that lit improperly. It's also possible that more than one lamp will light in place of the correct one.
7.	Twelve stable states per cycle.	(a) When lighting sequence is $0123^{01}_{45}456789$* the cause may be a failure of the first feedback or lowered cathode emission in first or second binary. (b) When the lighting sequence is $01234567^{23}_{89}89$ the cause may be failure of the second feedback or low cathode emission in third or fourth binary.

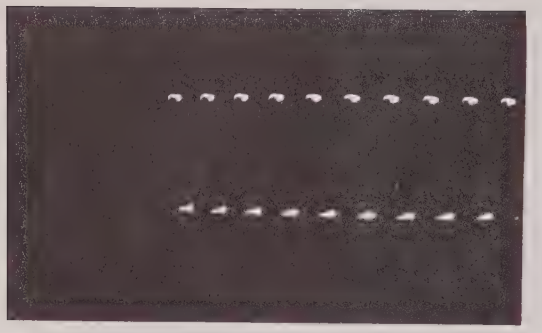
* One digit above another means both lamps are lit.

TABLE OF VOLTAGES & RESISTANCES

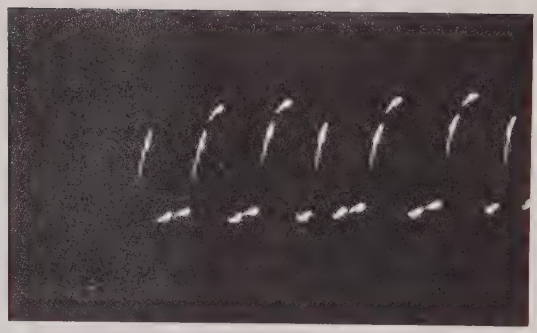
Tube	Pin No.	D.-C. Voltage with respect to B-.*	Resistance to B minus Terminal**
V101	1	170	105K
	2	17	85K
	3, 8	37	12K
	4, 5, 9	Filaments	
	6	60	105K
	7	37	85K
V102	1	135	93K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	93K
	7	30	83K
V103	1	135	100K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	100K
	7	30	83K
V104	1	135	93K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	93K
	7	30	83K

* Voltages measured in unit with 300-volt plate supply

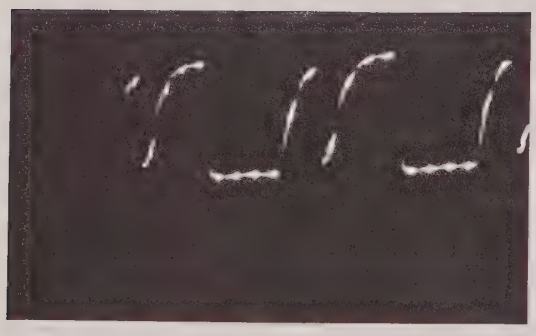
** Before making resistance measurements jumper pins 3 and 8 on the DCU plug.



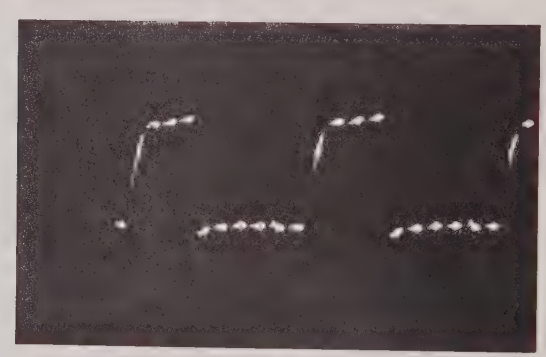
(1) First Binary Output (V101, Pin 6).
Upper voltage level is +168v
Lower voltage level is +55v



(2) Second Binary Output (V102, Pin 6)
Upper voltage level is +140v
Lower voltage level is +55v.

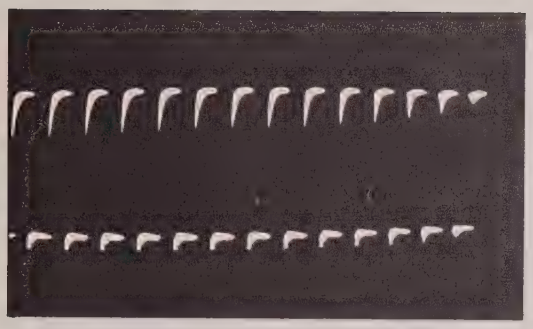


(3) Third Binary Output (V103, Pin 6)
Upper voltage level is +140v.
Lower voltage level is +55v.

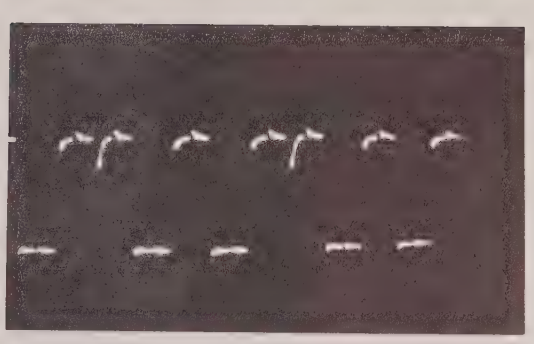


(4) Fourth Binary Output (V104, Pin 6).
Upper voltage level is +140v.
Lower voltage level is +55v.

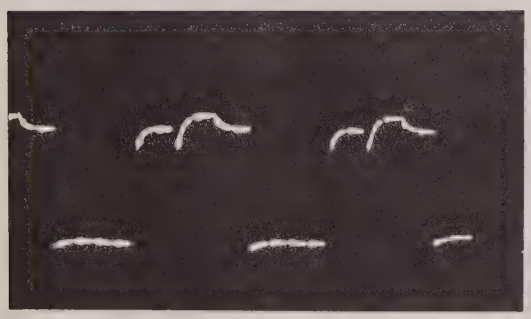
FIGURE 4. BLANKED WAVEFORMS AT INPUT FREQUENCY OF 20KC. ALL VOLTAGE LEVELS ARE MEASURED WITH RESPECT TO B MINUS.



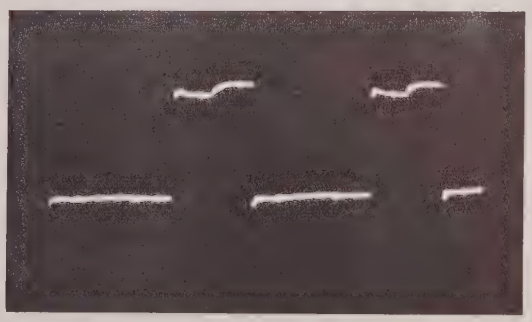
(1) First Binary Output (V101, Pin 6).
Upper Voltage level is +168V
Lower voltage level is +55v



(2) Second Binary Output (V102, Pin 6)
Upper voltage level is +140v
Lower voltage level is +55v.



(3) Third Binary Output (V103, Pin 6)
Upper voltage level is +140v.
Lower voltage level is +55v



(4) Fourth Binary Output (V104, Pin 6).
Upper voltage level is +140v.
Lower voltage level is +55v.

FIGURE 5. BLANKED WAVEFORMS AT INPUT FREQUENCY OF 100KC. ALL VOLTAGE LEVELS ARE MEASURED WITH RESPECT TO B MINUS.

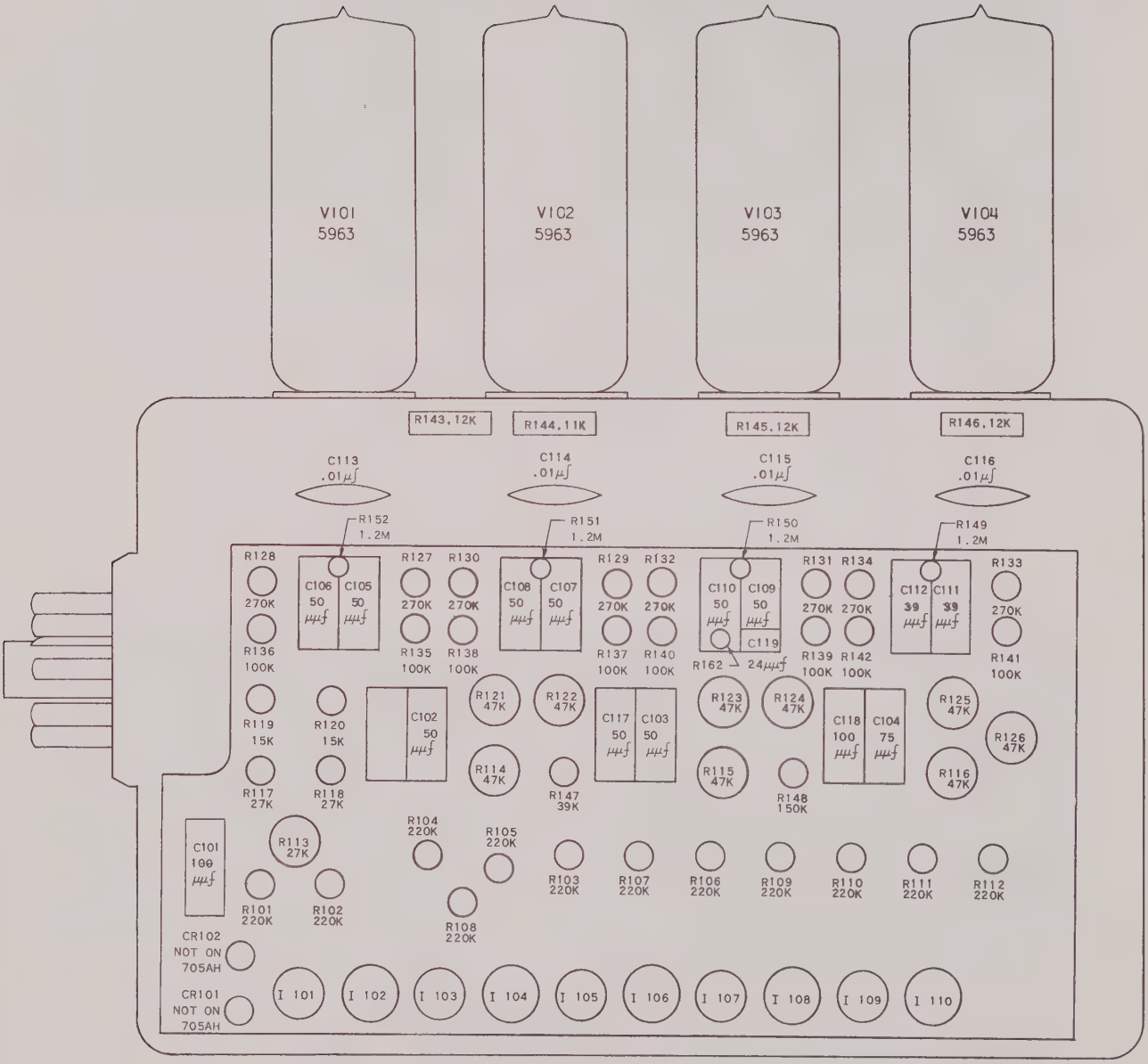
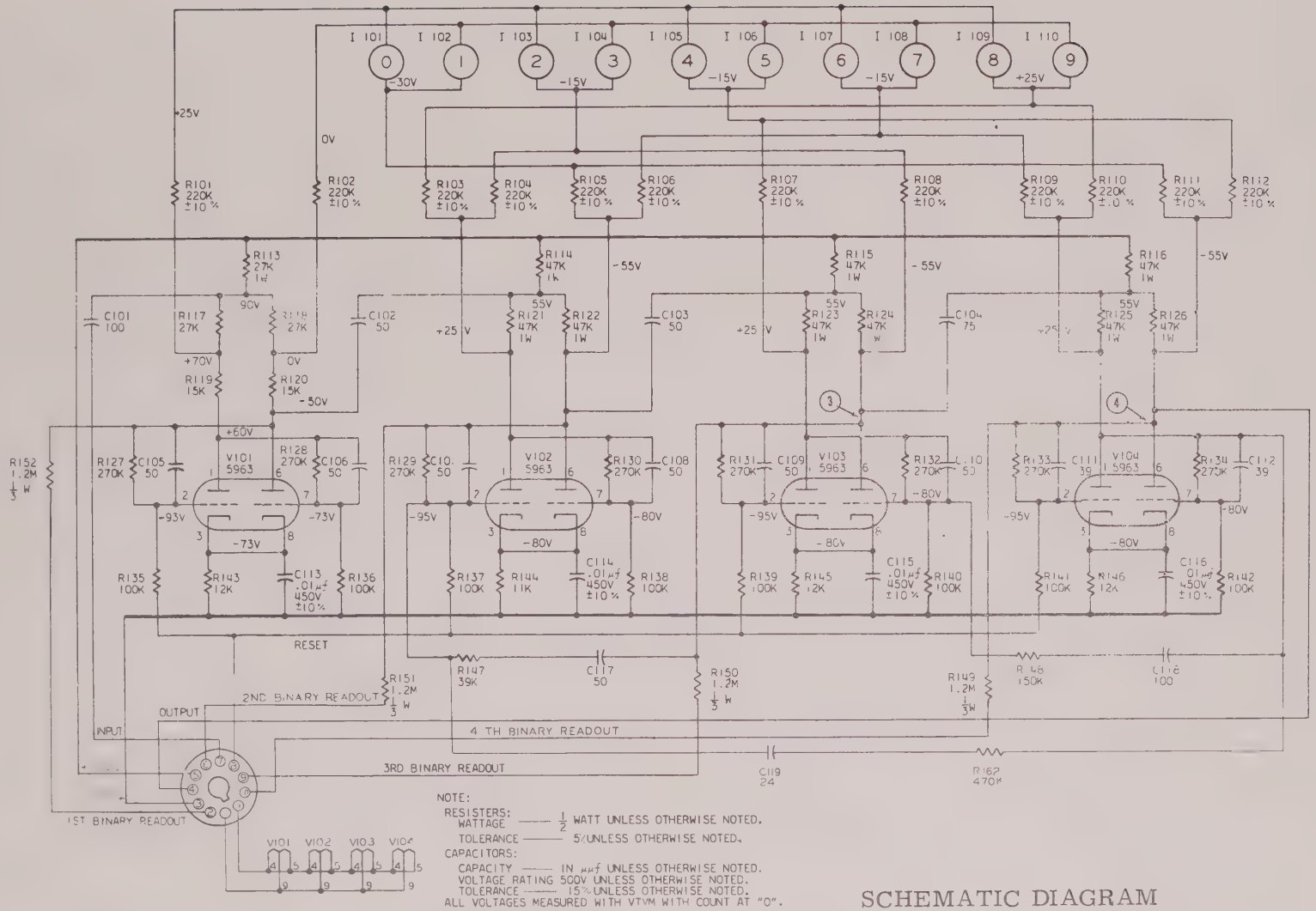
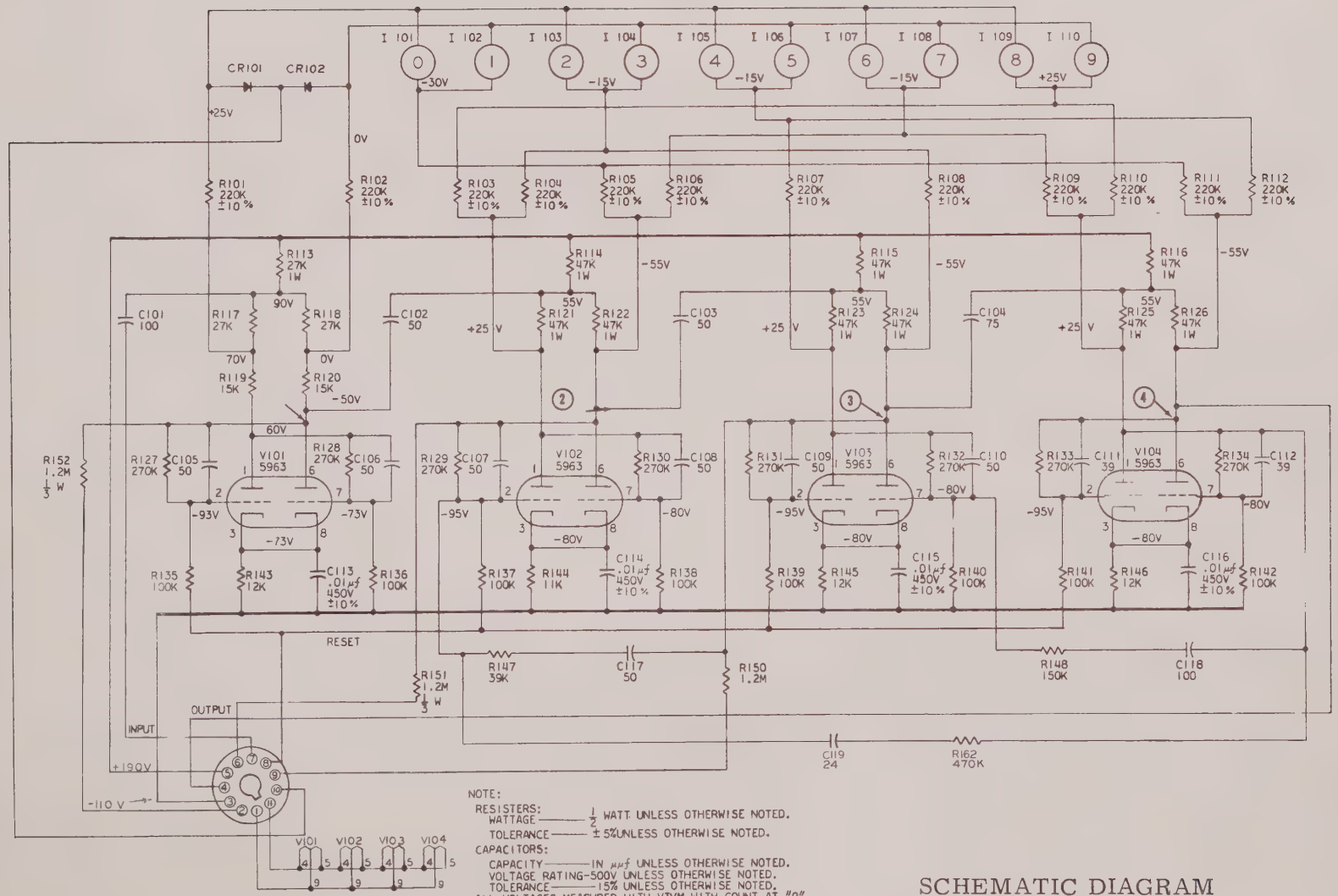


FIGURE 6. PARTS LOCATION

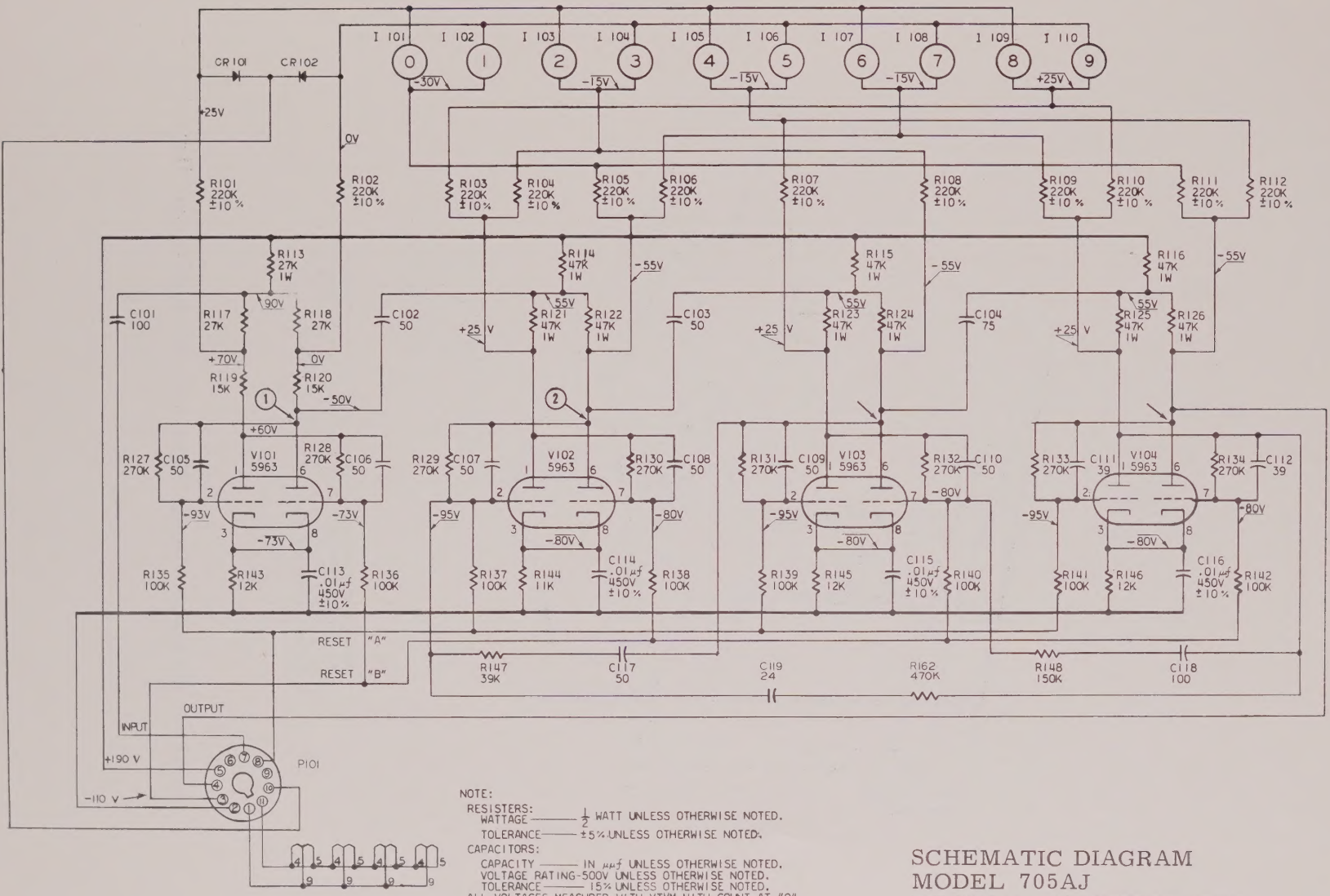


SCHEMATIC DIAGRAM
MODEL 705AH
DECIMAL COUNTING UNIT



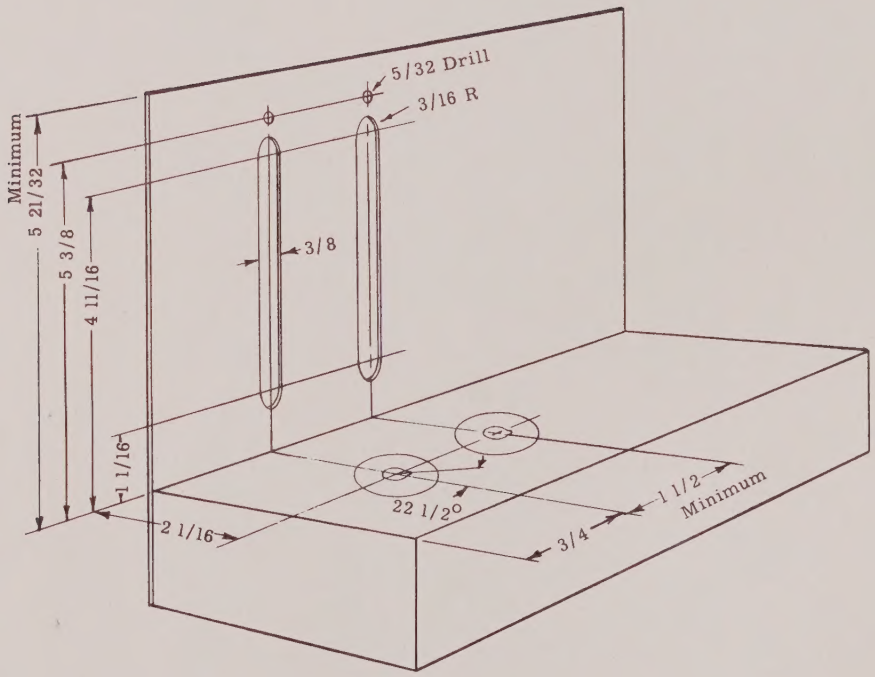
NOTE:
RESISTERS:
WATTAGE——½ WATT UNLESS OTHERWISE NOTED.
TOLERANCE——±5%UNLESS OTHERWISE NOTED.
CAPACITORS:
CAPACITY——IN μμf UNLESS OTHERWISE NOTED.
VOLTAGE RATING-500V UNLESS OTHERWISE NOTED.
TOLERANCE——15% UNLESS OTHERWISE NOTED.
ALL VOLTAGES MEASURED WITH VTVM WITH COUNT AT "0".

SCHEMATIC DIAGRAM
MODEL 705AK
DECIMAL COUNTING UNIT



NOTE:
RESISTERS:
WATTAGE ——— $\frac{1}{2}$ WATT UNLESS OTHERWISE NOTED.
TOLERANCE ——— ±5% UNLESS OTHERWISE NOTED.
CAPACITORS:
CAPACITY ——— IN μμf UNLESS OTHERWISE NOTED.
VOLTAGE RATING-500V UNLESS OTHERWISE NOTED.
TOLERANCE ——— 15% UNLESS OTHERWISE NOTED.
ALL VOLTAGES MEASURED WITH VTVM WITH COUNT AT "0".
AND PIN #10 DISCONNECTED.

SCHEMATIC DIAGRAM
MODEL 705AJ
DECIMAL COUNTING UNIT



NOTE: Dimensions are based on the use of an Amphenol "MIP" 8 or 11-pin socket mounted above the chassis.

The drawing shows chassis dimensions for mounting two Model 705A DCU's side by side. All modifications of the Model 705A (705AH, 705AF, etc.) have precisely the same dimensions as the standard 705A.

Mounting Dimensions, Model 705A and All Modifications Thereof